Linking Safety Culture & Safety Performance

In Marine Transportation

Martha Grabowski
Le Moyne College
Rensselaer Polytechnic Institute
grabowsk@lemoyne.edu
http://web.lemoyne.edu/~grabowsk
Twitter: grabowsk2

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Passing in Houston Ship Channel
http://pixdaus.com/pics/1285391280WU3sTdJ.jpg, Retrieved 24 October 2011

Overview *(2003-2011)*

Examine the linkage between safety culture and safety performance in the maritime industry

Partnership between

- **American Bureau of Shipping,**
- **U.S. Coast Guard,**
- **3 shipping companies**
  - ***1 U.S. domestic tanker operator***
  - ***1 International tanker operator***
  - ***1 International container operator***

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Retrieved 9 Dec 2007

Overview *(2003-2011)*

Investigate safety factors in the marine industry significantly linked to:

- **Human errors**
- **Near misses**
- **Accidents**
- **Incidents and**
- **Increased risk levels**

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Method

- **Develop model** *(leveraging previous aviation, risk, safety culture research)*
- **Collect and analyze data** *(correlation analyses)*
- **Secondary data analyses** *(binomial regression, structural equation modeling)*
- **Identify company-specific, trade-specific, and /or generic sets of indicators**
- **Evaluate links between safety culture and safety performance**

Overseas Houston http://www.osg.com/siteFiles/SiteManager/108074FE485F3B5B879DD6C3AB711C3A.jpg, retrieved 24 October 2011

Foundation--Risk Event Error Chain

Stage 1 Basic/ Root Causes

- Inadequate skills, knowledge, equipment, maintenance, management
- Human and organizational Errors
- Org'l culture

Stage 2 Immediate Causes

- Operational errors
- Judgment error
- Intentional error
- Hazardous situations

Stage 3 Incidents

- Equipment failure
- Propulsion failures
- Electrical system failures
- Steering failures
- Human failures

Stage 4 Accidents

- Collisions
- Groundings
- Allisions
- Ice collisions
- Fire & explosion
- Loss of containmt
- Lost cargo

Stage 5 Consequence

- Oil/chemical outflow
- Injury
- Vessel damage
- Persons in peril
- Loss of life

Stage 6 Impact

- Environmental damage
- Loss of life
- Vessel loss
- Loss of property

I. Decrease Frequency of Root/Basic Causes → II. Decrease Frequency of Immediate Causes or III. Exposure to Hazardous Conditions → IV. Intervene to Prevent Accident if Incident Occurs → V. Reduce Consequences if Accident Occurs → VI. Reduce Impact if Consequence Occurs

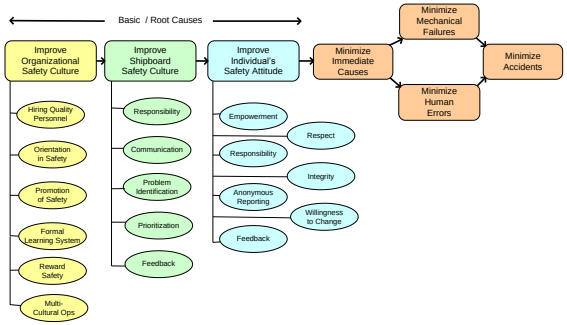
Risk Reduction Interventions

- *Safety Management Programs*
- *Channel Closure Restrictions*
- *Escort Vessels, Redundancy*
- *Double Hulls*
- *Booming and Containment*

Safety Culture, Performance

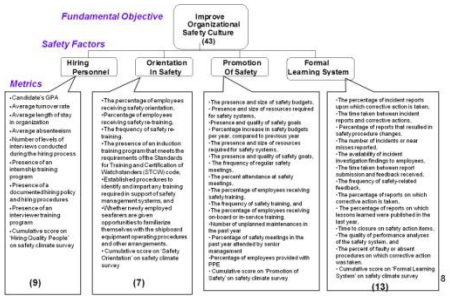
Safety factors

- *Characteristics, artifacts of culture*
- *Interviews, data gathering*



Safety factor metrics

Measuring characteristics of culture



Safety performance data

- *Accidents, incidents, near misses, conditions of class, port state deficiencies, LTI >= 3 days*
- *Survey data – perceived safety*
- *Validation data*
  - *US Coast Guard Marine Safety Mgmt System (MSMS), MISLE, MSIS, MinMod, CASMAIN, etc.*
  - *National Transportation Safety Board (NTSB) reports*
  - *UK MAIB database, Paris, Hong Kong MAIB*
  - *Lloyd's List, Equasis, NOAA oil spill databases*
  - *Coastal state, local, pilot, environmental, native data*
  - *Open source, proprietary, company-sensitive data*
- *Integration*

http://www.menkent.dk/cliffpics/lookout.jpg, retrieved 9 December 2007

Safety Factor Model

Senior Executive interviews ← *Vessel Leadership interviews* → *Safety, Health & Environmental Vetting interviews*

Basic / Root Causes

- Improve Organizational Safety Culture
  - Hiring Quality Personnel
  - Orientation in Safety
  - Promotion of Safety
  - Formal Learning System
  - Reward Safety
  - Multi-Cultural Ops
- Improve Shipboard Safety Culture
  - Responsibility
  - Communication
  - Problem Identification
  - Prioritization
  - Feedback
- Improve Individual's Safety Attitude
  - Empowerment
  - Respect
  - Responsibility
  - Integrity
  - Anonymous Reporting
  - Willingness to Change
  - Feedback
- Minimize Immediate Causes
  - Minimize Mechanical Failures
  - Minimize Human Errors
- Minimize Accidents

- *20 interviews over 3-year period*
- *Gather safety factor metrics and data*
- *Validate existing safety culture surveys – nuclear, chemical, aviation, offshore, medical*
- *Pilot test shipboard, shoreside safety culture surveys*

http://www.menkent.dk/cliffpics/lookout.jpg, retrieved 9 December 2007

Culture

- **A set of shared, basic, tacit assumptions about how the world is and ought to be** (Schein, 1992, 1996)
- **Determines perceptions, thoughts, behavior**

- ***Safety culture:* characteristics and attitudes in organizations and individuals that establish safety as an overriding priority** *(International Atomic Energy Administration, 1986)*
  - *Individual safety knowledge*
  - *Team, vessel safety culture, behavior*
  - *Organizational safety culture, behavior*

http://www.menkent.dk/cliffpics/lookout.jpg, retrieved 9 December 2007

Initial Research Framework

Organizational Safety Factors
Hiring Quality Personnel
Safety Orientation
Promotion of Safety
Formal Learning System
Reward Safety
Multicultural Operations

P1-P6

Organizational Safety Performance
accidents
incidents
near losses
of conditions of class
# of port state deficiencies
LTI>=3

Vessel Safety Factors
Responsibility
Communication
Problem Identification
Prioritization of safety
Feedback

P7-P11

Vessel Safety Performance
accidents
incidents
near losses
of conditions of class
# of port state deficiencies
LTI>=3

Individual Safety Factors
Empowerment
Responsibility
Anonymous Reporting
Feedback
Respect
Integrity
Willingness to Change

P12-P18

Individual Safety Performance
Perceived safety

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Safety Factor Metrics

Fundamental Objective

Improve Organizational Safety Culture (43)

Senior Executive Interviews

Safety Factors

Hiring Personnel

Orientation In Safety

Promotion Of Safety

Formal Learning System

Metrics

- Candidate's GPA
- Average turnover rate
- Average length of stay in organization
- Average absenteeism
- Number of levels of interviews conducted during the hiring process
- Presence of an internship training program
- Presence of a documented hiring policy and hiring procedures
- Presence of an interviewer training program
- Cumulative score on 'Hiring Quality People' on safety climate survey

(9)

- The percentage of employees receiving safety orientation,
- Percentage of employees receiving safety re-training,
- The frequency of safety re-training.
- The presence of an induction training program that meets the requirements of the Standards for Training and Certification of Watchstanders (STCW) code,
- Established procedures to identify and impart any training required in support of safety management systems, and
- Whether newly employed seafarers are given opportunities to familiarize themselves with the shipboard equipment operating procedures and other arrangements.
- Cumulative score on 'Safety Orientation' on safety climate survey

(7)

- The presence and size of safety budgets,
- Presence and size of resources required for safety systems,
- Presence and quality of safety goals
- Percentage increase in safety budgets per year, compared to previous year
- The presence and size of resources required for safety systems,
- The presence and quality of safety goals,
- The frequency of regular safety meetings,
- The percent attendance at safety meetings,
- The percentage of employees receiving safety training,
- The frequency of safety training, and
- The percentage of employees receiving on-board or in-service training.
- Number of unplanned maintenances in the past year
- Percentage of safety meetings in the past year attended by senior management
- Percentage of employees provided with PPE
- Cumulative score on 'Promotion of Safety' on safety climate survey

(14)

- The percentage of incident reports upon which corrective action is taken,
- The time taken between incident reports and corrective actions,
- Percentage of reports that resulted in safety procedure changes,
- The number of incidents or near misses reported,
- The availability of incident investigation findings to employees,
- The time taken between report submission and feedback received,
- The frequency of safety-related feedback,
- The percentage of reports on which corrective action is taken,
- The percentage of reports on which lessons learned were published in the last year,
- Time to closure on safety action items,
- The quality of performance analyses of the safety system, and
- The percent of faulty or absent procedures on which corrective action was taken.
- Cumulative score on 'Formal Learning System' on safety climate survey

(13)

Participants (2003 – 2011)

	Domestic Tanker	International Tanker	Container	Total
Shipboard	77	846	684	1607
Shoreside	22	97	38	157
Total Individual	99	943	722	1764
Vessels	7	39	56	102

- **Domestic US tanker operator** *(Initial and Follow up Study)*
- **International tanker operator** *(Initial study)*
- **International container operator** *(Initial study completed)*

Passing in Houston Ship Channel
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Safety Performance

Organization	Accidents	Incidents	Near Losses	Port State Deficiencies	Conditions Of Class	LTI >=3
Industry Partner 1	1*	N/A	60	6*	1*	7*
Industry Partner 2	31*	N/A	40	15*	16*	25*
Industry Partner 3	47	73	174	23*	39*	10*
Total	79	73	274	44	56	42

** = small sample size; t = 1 year; Table 5*

- Company proprietary data
- US Coast Guard Marine Safety Mgmt System (MSMS), MISLE, MSIS, MinMOD, CASMAIN, etc.
- Coastal states, pilot organization, environmental groups' data
- National Transportation Safety Board reports
- UK MAIB, Hong Kong Marine Dept, Paris, Equasis databases
- Lloyd's List, NOAA spill databases

Open source, proprietary, company-sensitive data

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Organizational Safety Results

- **Safety Factor Categories**
  - ***Hiring Quality Personnel***
  - Safety Orientation
  - ***Promotion of Safety***
  - ***Formal Learning System***
  - Reward Safety
  - Multicultural Operations
- **Safety Performance Measures**
  - Number of accidents
  - Number of incidents
  - ***Number of near losses***
  - Number of Conditions of Class
  - ***Number of Port State Deficiencies***
  - Number of LTI≥ 3 days

Highlighted Organizational Safety Factors
were significant for highlighted Performance Measures

SeaRiver American Progress
http://www.marinelink.com/images/show.aspx?aid=3953&width=310&height=500&/american-progress2_web.jpg

Vessel Safety Results

- **Safety Factor Categories**
  - ***Communication***
  - ***Responsibility***
  - ***Problem Identification***
  - ***Feedback***
  - Prioritization of Safety

- **Performance Measures**
  - ***Number of accidents***
  - Number of incidents
  - ***Number of near losses***
  - Number of Conditions of Class
  - Number of Port State Deficiencies
  - Number of LTI≥ 3 days
  - Perceived Safety based on Survey results

Highlighted Vessel Safety Factors
were significant for highlighted Performance Measures

SeaRiver American Progress
http://www.marinelink.com/images/show.aspx?aid=3953&width=310&height=500&/american-progress2_web.jpg

Individual Safety Results

- **Safety Factor Categories**
  - ***Empowerment***
  - Responsibility
  - ***Anonymous Reporting***
  - ***Feedback***
  - Respect
  - Integrity
  - Willingness to Change
- **Performance Measures**
  - ***Number of accidents***
  - Number of incidents
  - ***Number of near losses***
  - Number of Conditions of Class
  - Number of Port State Deficiencies
  - Number of LTI≥ 3 days
  - ***Perceived Safety based on Survey results***

Highlighted Individual Safety Factors
were significant for highlighted Performance Measures

SeaRiver American Progress
http://www.marinelink.com/images/show.aspx?aid=3953&width=310&height=500&/american-progress2_web.jpg

Individual Safety Factor Metrics (example)

Leading Indicator Categories	Standard Metrics for Assessing the Leading Indicators
Individual	*Perceived safety = dependent variable*
Empowerment	**M 6: Employees' average length of stay in the organization.**
	M 7: Employees' average absenteeism in the past year.
	M 8: Employees' satisfaction with the influence he/she has on health and safety performance in the organization.
	M 9: Employees' perception of the control he/she has over safety outcomes of the job.
	M 10: Employees' satisfaction with his/her involvement in the safety of the vessel.
	M 11: Employees' perception of his/her involvement when health and safety procedures are being developed.
	M 12: Employees' perceptions of his/her influence on the safety decisions being made by superiors.

Bold metrics are objective (quantitative) metrics. Regular font are subjective metrics.

Initial Study Limitations

- **Correlations, not causality**
  - Higher order statistical analyses followed (SEM, binomial regression)
- **Longitudinal assessments needed**
  - Within, and cross-organizational analyses
  - Benchmark results vs. other safety factor studies
- **Small # of organizations (n = 3 companies)**
  - Trend analyses require further data collection
- **Safety factors and metrics provide starting point for measurement over time**

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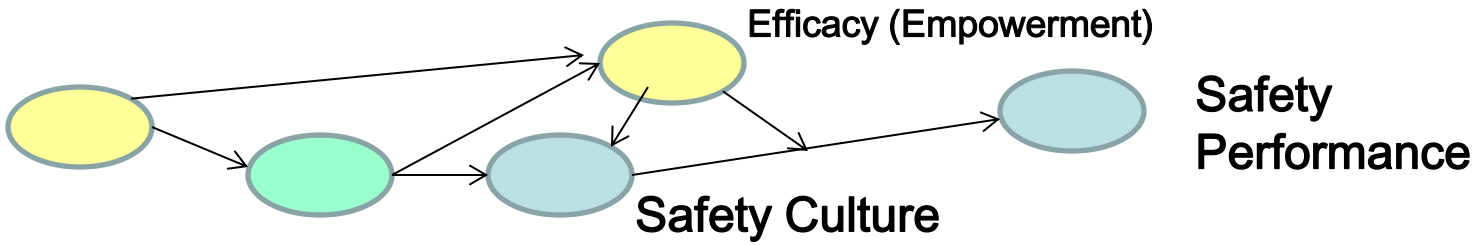
Retrieved 24 October 2011

Secondary Analysis *(2011-2013)*

- ***Network* of safety culture influences**
  - *(DeJoy, et al., 2004; Neal, et al, 2000; Zohar, 1980; 2003).*



- ***Assumption: When safety culture (climate) high, workers perceive safety as critical***
  - Workers & supervisors actively make causal inferences about safety *(DeJoy, 1994; Hofmann & Stetzer, 1998)*
  - Workers are motivated to be proactive in identifying & correcting anomalies *(O'Dea & Flin, 2001; Parker, et al., 2003; Simard & Marchand, 1995)*

Overseas Houston
http://www.osg.com/siteFiles/SiteManager/108074FE485F3B5B879DD6C3AB711C3A.jpg, retrieved 24 October 2011

Efficacy's Moderating Effect
on Team (Vessel) Performance

Safety Culture

*H1, H2***, H3Alt****

Safety Performance
- # accidents
- # unplanned maintenance
- # safety suggestions

N = 23 vessels
(vs. 102; 239 vessels; missing data)

*H4A, H4B***, H4CAlt*****

- *Vessel level*
- *Negative binomial regression*
- *Accidents: Zero-inflated negative binomial regression*

Worker Efficacy

Efficacy (Behavioral proactivity) motivates safety improvements
--fewer accidents
--fewer unplanned maintenance activities
--more (or fewer?) safety suggestions

Efficacy: Perceived ability to exert control over outcomes
(Bandura, 1977; 1997)
--measured at individual level, aggregated

Overseas Houston
http://www.osg.com/siteFiles/SiteManager/108074FE485F3B5B879DD6C3AB711C3A.jpg, retrieved 24 October 2011

Assumptions about Safety Culture

Vessel Efficacy

Safety Culture	Low	High
High	<----------- Lower Stress ----------→ ←----------Lower Uncertainty ---------→ ←----------Proactive problem solving-→	
Low	<----------- High Stress ----------→ ←----------High Uncertainty ---------→ ←----------Reactive problem solving-→	

Overseas Houston http://www.osg.com/siteFiles/SiteManager/108074FE485F3B5B879DD6C3AB711C3A.jpg, retrieved 24 October 2011

Safety Culture and Vessel Performance

…moderated by Vessel Efficacy

Vessel Efficacy

Safety Culture	Low	High
High	• More accidents • More safety suggestns	• Fewer accidents
Low	• Even more accidents • More safety suggestns	• More unplanned maintenance

<----------------- More accidents ----------->

<----------More unplanned maintenance---------->

•*Negative binomial regression*
• *Accidents: Zero-inflated negative binomial regression*

N = 23 vessels

(vs. 102; missing data)

Overseas Houston http://www.osg.com/siteFiles/SiteManager/108074FE485F3B5B879DD6C3AB711C3A.jpg, retrieved 24 October 2011

Implications

- ***Networks*** **of safety culture influences**
- **Moderating influence of efficacy/empowerment**
- **Safety culture manifests at different org'l levels**
  - Safety culture metrics, rewards, incentives vary across organizational levels
- **Safety factors linked to safety performance**
  - Organizational – Hiring Quality People, Promote Safety, Formal Learning System
  - Vessel – Communication, Responsibility, Problem ID, Feedback
  - Individual – Empowerment, Anonymous Reporting, Feedback
- **Safety performance impacts vary by level**
  - Near loss metric significant across all levels
  - Near loss measurement systems provide safety performance lens across levels

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Retrieved 24 October 2011

Implications

- **Efficacy/empowerment can be maladaptive**
  - Especially with high safety culture
  - Not particularly helpful –maladaptive--in uncertain, high stress and reactive problem solving settings

- **Multi-level, network data analyses**
  - Secondary data analysis provides new insights
  - Initial correlation analysis → Zero-inflated binomial regression
- **Process: Partnerships were key**
- **Next steps: Networks of linked networks**
  - Missing nodes, influential nodes

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Passing in Houston Ship Channel
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